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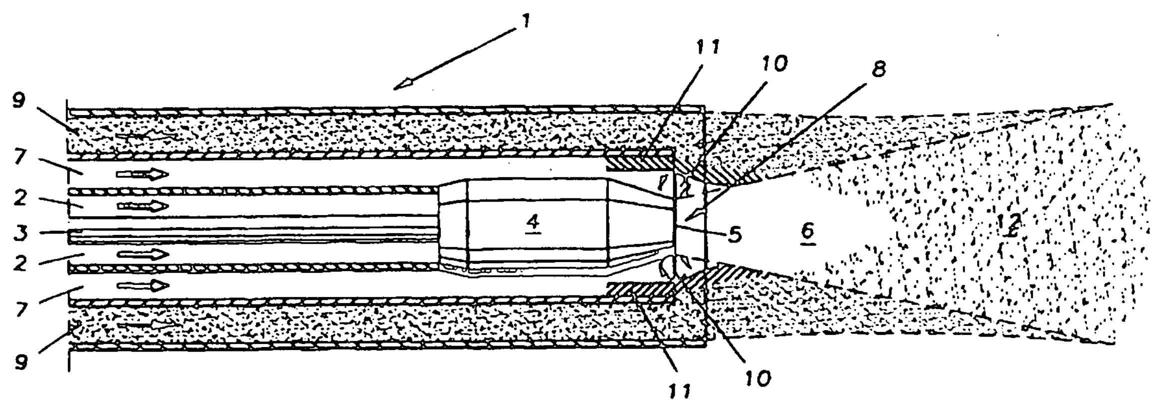
(54) Title: NOZZLE IMPULSE CONTROLLED VENT AIR FLOW



(57) Abstract

A nozzle arrangement intended for introducing into a process gas an adsorbent material which is reactive with the gas, or for delivering barrier-air to a dust-containing environment. The nozzle arrangement includes pressurized gas or liquid delivery channels (2, 3), a nozzle (4) in which the liquid is finely-divided, and a nozzle orifice (5) through which the finely-divided liquid is ejected, and a peripherally disposed annular channel (9) through which dry adsorbent material is delivered. The nozzle arrangement also includes a further annular channel (7) which is disposed inwardly of the channel (9) and surrounds the nozzle (4). The end of the annular channel (7) distal from the nozzle is in open connection with a space in which the level of pressure is equal to or higher than the level of pressure in the working environment of the nozzle, and preferably in open connection with a space in which atmospheric pressure prevails, whereby the pressure difference between the two spaces generates a flow of barrier-air in the channel (7), this flow being regulated by and in direct proportion to the nozzle impulse. In relation to the nozzle orifice, the cross-sectional area of the barrier-air channel (7) is sufficiently great to generate a barrier layer of barrier-air radially inwards of the flow of adsorbent material and to maintain this barrier, so as to prevent dust from admixing with the gas recirculating from the spray cone.

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Nozzle impulse controlled vent air flow

The present invention relates to a nozzle or liquid nozzle arrangement for delivering to a process gas adsorbent material which reacts with contaminants in the gas, or for delivering barrier-air into a dust-containing environment. The invention relates particularly to such a nozzle with the intention of preventing the build-up of solid substances around the nozzle orifice.

The invention finds application, for instance, in a contact reactor for separating acid-forming substances such as sulfur dioxide, and the like, from flue gases, wherein water-suspended adsorbent material is injected into the reactor for reaction with said contaminants. The delivery and moistening of the adsorbent, which in some cases can be partially recycled for renewed use, is normally effected with the aid of a nozzle which includes delivery channels for compressed air and suspension respectively. The water or the suspension is finely divided, or atomized, in the nozzle by the compressed air, and then injected into the reactor, wherein the nozzle orifice may be configured aerodynamically to prevent release and recirculation of gas from the spray cone. Examples of nozzles intended for this purpose are found in EP-185 630 and U.S. 4,625,916. A particular form of nozzle is comprised of the so-called MDI (Moisture Dust Injection) nozzles, in which water and dry adsorbents are delivered separately for atomization and subsequent mixture to form a dust-containing reaction gas.

One problem with installations of this kind resides in avoiding the build-up of adsorbent material on the outer surfaces of the nozzle orifice, this build-up of deposits being the result of turbulence and the recirculation of the moist adsorbent material caused by the subpressure that prevails at the root of the spray cone externally of the nozzle orifice. The build-up of solid substances on the nozzle therewith increases recirculation of the moist adsorbent and an accelerating

process occurs which ultimately results in serious impairment of the nozzle function and therewith reduced process efficiency.

An attempt to avoid these problems is described in SE-447 704 which describes a nozzle having an outwardly mounted shield which functions to create a barrier layer of barrier-air around the nozzle orifice and in this way prevents recirculation of the gas mixture of the media spray. The nozzle construction includes a variable number of symmetrically disposed orifices or nozzles with internal mixing and finely-dividing of water and a medium, such as lime for instance. In brief, pressurized barrier-air is controlled and directed from a gap in the region of the nozzle periphery generally perpendicular to the media spray and towards the centre of the nozzle. The barrier-air is said to be delivered at a speed which equals about 25-30% of the speed of the media spray. It will be understood that the construction cannot achieve effective barrier, primarily on the lee side of the media spray, i.e. in the centre of the nozzle, and consequently there is a danger that solid material will settle at least in this region.

The present invention provides a nozzle arrangement which eliminates the risk of dust/adsorbent material settling around a nozzle orifice or a liquid nozzle used to moisten dust in the spray cone, by creating a barrier layer of barrier-air which prevents the admixture of dust-containing gas in that part of the gas that recirculates to the orifice of the nozzle.

Coaxially inwardly of an annular channel through which a dry, powdered material is delivered, and coaxially outwards of a nozzle body for compressed-air atomization or pressure atomization of a liquid, there is delivered in accordance with the invention barrier-air with a given speed profile and with such an area as to generate a barrier layer of barrier-air between the recirculation zone of the nozzle and the adsorbent

unavoidable release of the gas flow at the nozzle orifice of the nozzle body and the there prevailing subpressure which generates turbulence and recirculation of gas from the spray cone can be accepted in practice, because the thus generated barrier layer prevents the admixture of dust or adsorbent material in the region where recirculation takes place.

In this regard, the speed at which the barrier-air is delivered shall be greater than or equal to the speed at which the adsorbent material is delivered, and may be lower than or equal to the muzzle velocity of the liquid nozzle.

This is achieved in accordance with the invention by connecting a barrier-air introducing channel to a space in which the pressure level is equal to or higher than the level of pressure in the working environment of the nozzle, and by controlling the speed profile of the barrier-air flow in response to pressure changes in the nozzle impulse. The barrier-air flow will thereby always be proportional to the nozzle power or nozzle impulse, so as to maintain the desired barrier layer. One requirement in this regard is that there prevails between said space and the nozzle environment a pressure relationship which causes the nozzle impulse to present more than a marginal effect on the speed of the barrier flow. For instance, in the case of a flue-gas cleansing contact reactor, the invention provides a particularly beneficial solution from an economical and an installation-technical aspect, in that the barrier-air channel is connected to a space in which atmospheric pressure prevails, whereby biassing of the barrier-air flow can be said to exist by virtue of the subpressure prevailing in the reactor.

The object of the invention is therefore to achieve in a liquid nozzle a barrier-air flow which is proportional to the nozzle impulse, so as to establish and maintain a barrier-air layer which will prevent the admixture of dust-containing gas with the recirculating part of the gas flow.

This object is achieved with an arrangement according to Claim 1.

The invention will now be described in more detail with reference to an exemplifying embodiment thereof and also with reference to the accompanying schematic drawings, in which

Fig. 1 illustrates the inventive arrangement applied to a nozzle at one end of a lance for delivering reactive material to a process gas;

Fig. 2 is an overview which illustrates the lance of Fig. 1 applied in a flue-gas cleansing contact reactor;

Fig. 3a is a cross-sectional view of the inventive arrangement applied in a boiler of a combined power and heating plant for metering urea-water solution and adsorbent thereto; and

Fig. 3b is a detailed cross-sectional view of the nozzle orifice region of the application shown in Fig. 3a.

Fig. 1 illustrates a nozzle arrangement, generally designated 1, which can be said to form the outlet end of a lance 1 and which includes compressed-air conducting channels 2 and liquid conducting channels 3, said liquid being water, urea, etc. The channels 2 and 3 may be coaxial with one another. A nozzle or nozzle 4 forms an atomizing chamber in which the liquid is atomized prior to being blown out through the nozzle orifice 5 in the form of a spray cone 6 of liquid mist or gas. Since the internal construction of the nozzle 4 is not critical in achieving the advantages afforded by the invention, it will not be described in detail, and it will be understood that the nozzle may be constructed from any known and conventional components by means of which the liquid can be atomized by means of compressed air. Alternatively, the nozzle may be constructed to pressure-atomize the liquid, i.e. without the

described embodiment assumes that the liquid is atomized with the aid of compressed air.

Extending coaxially around the channels 2, 3 and the nozzle 4 is an annular channel 7 through which barrier-air is introduced. As will be seen from Figs. 2 and 3a, the other end of the channel 7 is connected to a space in which the level of pressure is equal to or higher than the level of pressure in the working environment of the nozzle, preferably with a space in which atmospheric pressure, or a pressure close to atmospheric pressure, prevails.

Extending coaxially with the aforesaid channels is a further annular channel 9, through which a dry dust-like adsorbent is introduced, said adsorbent being fed through the channel 9 with the aid of compressed air or some other transport gas for admixture with the liquid mist in the spray cone 6. The channels 7 and 9 are suitably rectilinear in the outlet region of the lance 1 and preferably along a substantial part of their extension, so as to promote a shear-free and turbulence-free outflow of barrier-air and particulate material, and so that the flow of materia in the channels will be disturbed to the least possible extent.

Because of the subpressure that prevails in the root 8 of the spray cone, turbulence and recirculation of the finely-divided liquid will occur around the outlet orifice of the nozzle. This is illustrated in Fig. 1 with arrowed circles 10. As a result of the subpressure that is generated by the nozzle impulse, barrier-air 7 is drawn through the channel 7 from the space under atmospheric pressure or a pressure close thereto. In this regard, the cross-sectional area of the channel 7 is sufficient for the barrier-air to establish a peripheral flow of barrier layer 11 which remains unaffected by the turbulent flow 10 and prevents admixture of the dust/adsorbent with the spray cone 6 in the region of the nozzle orifice 5. Thus, admixture of dust with the mist is delayed and takes place at a location 12

downstream of the nozzle orifice, and consequently the recirculating part 10 of the gas mixture is free from dust and can therefore be accepted, because it does not lead to the deposit of solids on the nozzle surfaces.

As a guide line to the skilled person when dimensioning the barrier-air channel 7 reference is made to the following practical example, in which the ratio of the cross-sectional area of the barrier-air channel to the orifice area of the nozzle is in the order of about 15/1 and about 30/1 respectively. These ratios, however, shall not be considered as outer limits at which the advantages of the invention are achieved, but that in each application the nozzle spray angle and the radial distance of the flow of adsorbent material to the spray cone will be taken as a controlling factor for the individual design of the barrier-air channel. For instance, a ratio as low as about 1.7/1 will be achievable when the nozzle design is intended to generate a spray cone having a very small cone angle.

Fig. 2 illustrates schematically the application of an inventive nozzle arrangement in a process-gas cleansing contact reactor 20. The illustrated nozzle arrangement forms the outlet end of a lance 1 and is inserted into a reactor space 21 to enable moist adsorbent material to be injected into said space, or chamber, in the movement direction 22 of the process gas. The lance 1 includes conventionally inlets for compressed air 2, liquid 3 and adsorbent 9, and in the case of the inventive embodiment also includes a channel 7 which is open to atmospheric pressure.

As a result of the nozzle impulse or the speed of the medium in the nozzle, there is created in the region of the nozzle outlet end a subpressure which is used directly to draw barrier-air through the channel 7 from a space in which atmospheric pressure, or a pressure close to atmospheric

thereby proportional to the nozzle impulse and requires no mechanical means for controlling the flow. The term "nozzle impulse" shall be understood to include in this context the combined impulse that is generated by the atomized liquid and adsorbent material with transport gas.

Practical tests have shown that the desired effect is achieved in an application for removing sulfur dioxide from flue gases deriving from a combustion process carried out in a combined power and heating plant, by injecting moist calcium hydroxide with the aid of the inventive nozzle arrangement.

In accordance with Fig. 2, a lance having a nozzle of relevant kind was installed in a contact reactor in a peat/coal fired combined power and heating plant of 400 MW. Water was delivered to the nozzle body at a pressure of 6 bars and at a rate of 300-400 kg/h, and was atomized therein and then ejected into the reactor with the aid of compressed air at a pressure of about 5 bars. A mixture of calcium hydroxide and fly ash suspended in air was delivered to the reactor at a rate of about 2000 l/h and at a speed of about 20 m/s, for mixture with the liquid mist downstream of the nozzle orifice and for reaction with the sulfur contaminants in the flue gas. The barrier-air channel was connected to a region of atmospheric pressure externally of the reactor, and as a result of the subpressure generated in the root of the spray cone air was delivered through said channel at a speed of 40-60 m/s controlled by the nozzle impulse. The cross-sectional area of the barrier-air channel was adapted to produce a peripheral, annular barrier layer, and had a diameter of 67 mm, which is placed in relationship with the nozzle orifice diameter of 16 mm. In this case, the lance had an outer diameter of 102 mm.

The installation was kept operating for four weeks and was found to function without disturbance and to reduce the incoming sulfur dioxide content by 75%. Check were repeatedly carried out, none of which showed the build-up of solid

substances on the nozzle body, which can only be seen as an indication that the inventive nozzle arrangement produced the effect desired.

In another case, a urea-water solution was metered into the boiler of the combined power and heating plant through lances mounted in twelve flue-gas return ports having a diameter of 230 mm, with the intention of reducing sulfur contaminant concentrations in the flue gases. Powdered adsorbent (dolomite $CaCO_3$ $MgCO_3$) was also metered through the ports and calcined to CaO in the furnace, which in turn reacted with SO_3 to form $CaSO_4$. The method achieved a sulfur reduction of 40-50%.

Urea was injected in the ports, partly because of the temperature level of the furnace, and partly to utilize the recirculated flue gas for distribution and admixture of the adsorbent material. Urea (NH_2) 2CO reacts with 2NO to form 2N2 + $2H_2O$ + CO. In the case of this method, it is extremely important that the spray cone generated by the urea nozzle will not be disturbed by the build-up of deposits on the nozzle, since the urea solution is highly corrosive in boiler environments (high temperature and reducing gases). Contact of urea solution with the tube wall will result in penetrative corrosion within the space of two calendar days.

The use of the inventive barrier-air system in this installation showed splendid results in all twelve nozzles tested over a period of twenty-five weeks.

The installation is described in more detail below with reference to Figs. 3a and 3b, wherein Fig. 3a is a cross-sectional view of one of the twelve gas return ports 30, all of which are of mutually the same construction.

A urea solution having a concentration of 10-30 percent by weight was introduced through a lance 31 at a pressure of 3-6

solution and inject the atomized solution into the plant furnace 32. The port 30 opens into the furnace wall between boiler tubes 33.

Adsorbent (dolomite) was passed through a channel 34 at a rate of 150-300 kg/h with the aid of a transport gas flow of 20-30 m/s, with the intention of mixing the adsorbent with the urea solution in the boiler furnace. The channel 34 was terminated with a nozzle 35 which discharged into a flow of recirculating flue-gas 36, intended to support the distribution and admixture of the adsorbent material. The flue-gas flow 36 had a speed of 40-70 m/s and a sustained temperature of 140-160°C.

Barrier-air 37 was drawn by suction in through an annular channel 38, whose outer end 39 was open to atmospheric pressure. In accordance with the aforegoing, the channel 38 is disposed coaxially between the flow of adsorbent and the moistening flow and is dimensioned to maintain therebetween a barrier-air layer in order to prevent dust admixing with the spray cone, such that recirculating parts of the gas will remain free from particles and not result in the build-up of solid substances.

Accordingly, in the illustrated embodiment (see Fig. 3b), the nozzle 39 has an orifice diameter a of 10 mm and is designed to have a spray angle d of 90°. The barrier-air channel 37 has an internal diameter b of 55 mm and the diameter c of the flue-gas port orifice is 230 mm.

The aforedescribed practical examples can be seen as proof that the object of the invention is achieved with the inventive arrangement. It will be noted, however, that the dimensions stated are only given by way of example and as a guideline to one skilled in this art, and that each application will have its own exclusive and optimal design. It will also be understood that the barrier-air channel 7 may advantageously discharge in the region of or vertically in line with the nozzle

orifice 5, which provides the best condition for maintaining the barrier layer 11, since the radial distance between the spray cone and the outer periphery of the barrier-air channel is greatest in this region. It will also be understood that the arrangement will provide important advantages from an economical and installation aspect when the outer end of the barrier-air channel is open to atmospheric pressure, and that the self-regulating and nozzle-impulse controlled flow will promote an unimpeded flow through the barrier-air channel. It will also be understood that the scope of the invention is not restricted to this particular embodiment and that the advantages afforded by the invention are also achieved when the barrier-air channel opens into a space in which the level of pressure is slightly below or slightly above atmospheric pressure, although it will be understood that there may not prevail a critical pressure relationship which would result in turbulent flow in said channel and the loss of the barrier layer.

CLAIMS

1. A nozzle arrangement (1) for delivering to a process gas an adsorbent material which reacts therewith, or for delivering barrier-air to a dust-containing environment, said nozzle arrangement comprising pressurized gas or pressurized liquid (2, 3) channels; a liquid atomizing nozzle (4); a nozzle-like orifice (5) through which the atomized liquid or gas is blown-out in the form of a spray cone, a peripherally arranged annual channel (9) through which dry dust or particulate material is delivered, and an annular channel (7) which is disposed inwardly of the first-mentioned annular channel (9) and surrounds the nozzle (4), and which delivers barrier-air around the nozzle orifice (5), **characterized** in that the barrier-air channel (7) is connected to a space in which atmospheric pressure, or a pressure close to atmospheric pressure, prevails such as to obtain through the channel (7) an unhindered flow of barrier-air directly controlled by and established by the nozzle impulse.

2. A nozzle arrangement according to Claim 1, **characterized** in that the cross-sectional area of the barrier-air channel (7) in relation to the nozzle outlet (5) is sufficiently great to generate in the outlet end of said channel an annular barrier layer of barrier-air which is orientated peripherally in said channel and which remains uninfluenced by the recirculating part of the gas/liquid mixture in the nozzle spray cone, wherein the ratio between the two cross-sectional areas is at least in the order of 1.7/1 and preferably within a range of 1.7/1 to 30/1.

3. A nozzle arrangement according to Claim 1 and Claim 2, **characterized** in that the barrier-air channel (7) discharges opposite to or in the proximity of the nozzle orifice (5).

4. A nozzle arrangement according to any one of the preceding Claims, **characterized** in that the barrier-air channel (7) is

rectilinear in the region of its discharge orifice, and preferably along a substantial part of its extension.

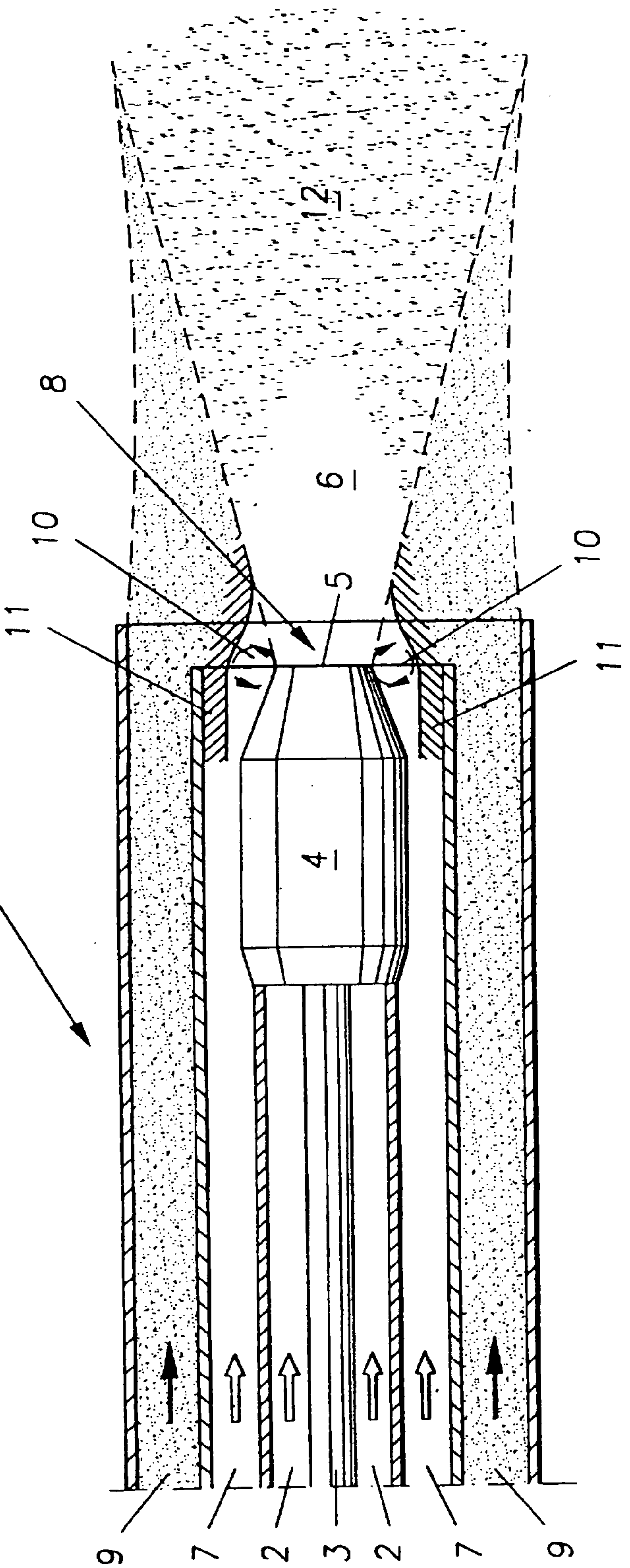


Fig 1

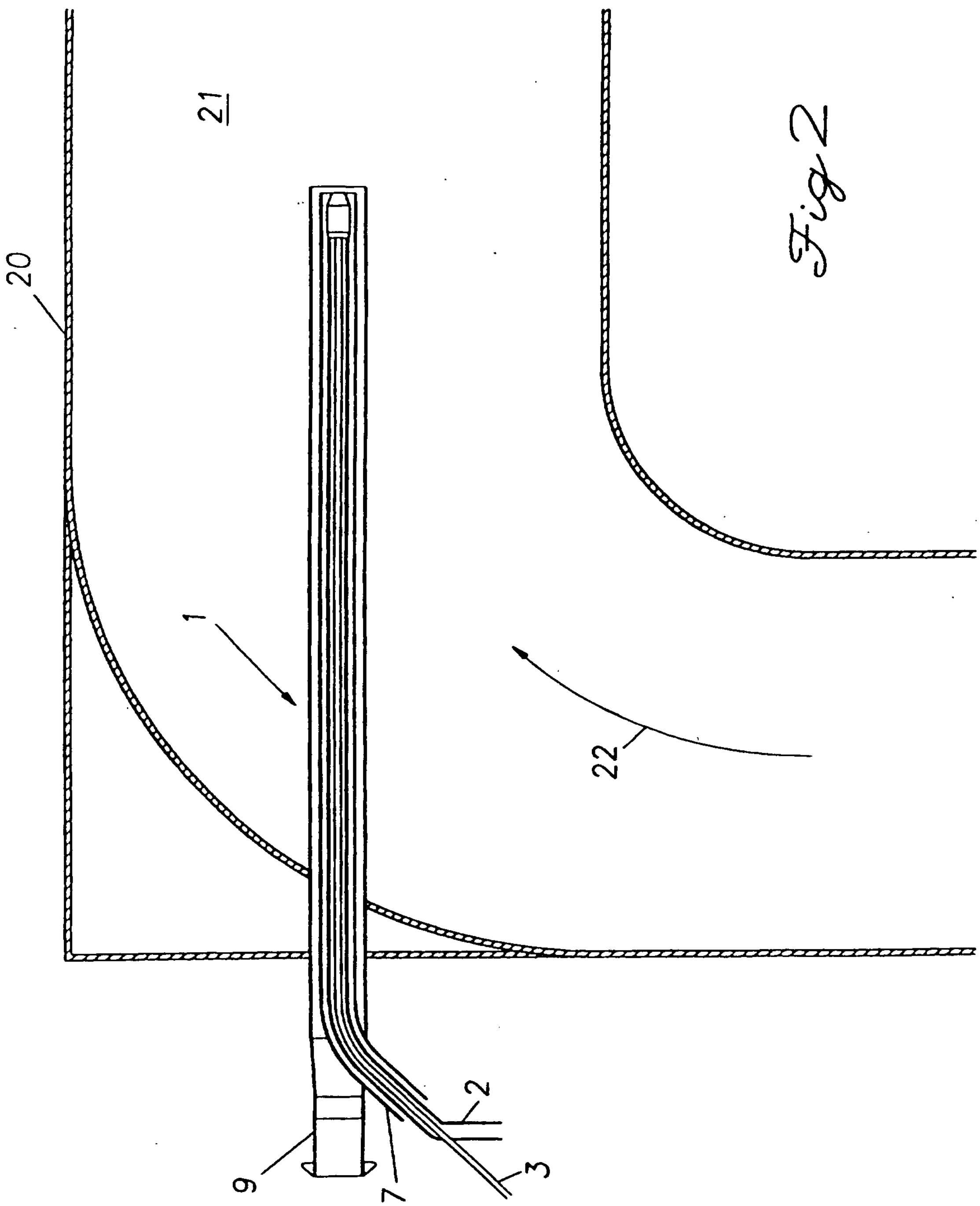
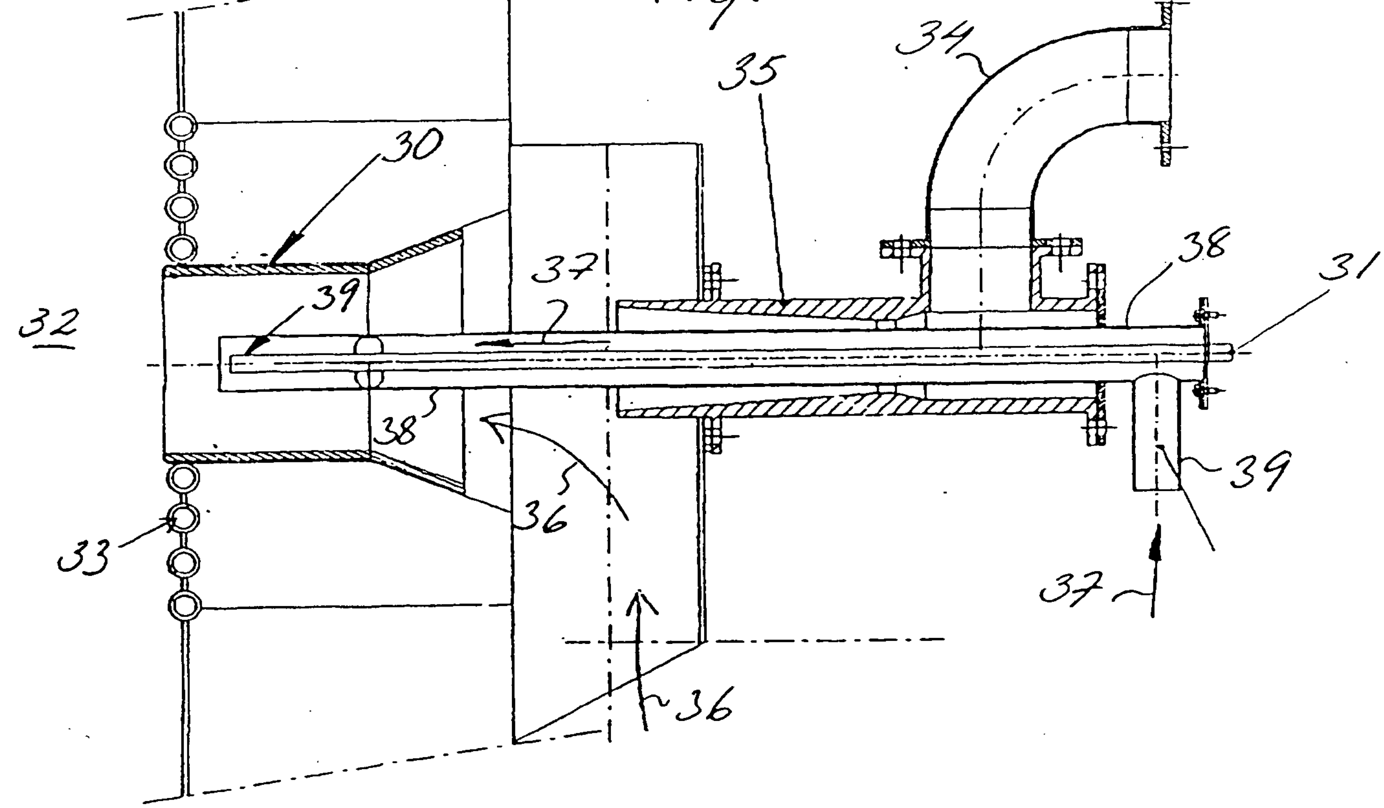


Fig 2

Fig. 3a



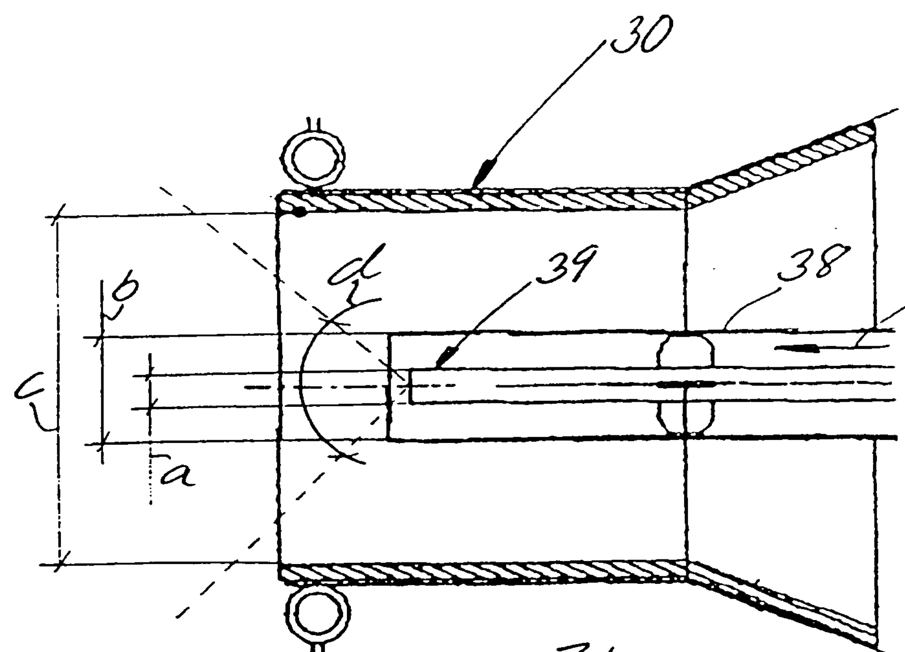


Fig 3b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/01093

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B05B 7/06, B05B 15/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B05B, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category°	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5209915 A (JOHN H. KIDWELL), 11 May 1993 (11.05.93), column 2, line 49 - line 65, figures 1, 2, abstract --	1
A	EP 0185630 A1 (FLÄKT AB), 25 June 1986 (25.06.86), abstract --	1
A	US 4625916 A (WOLFGANG NIEUWKAMP ET AL), 2 December 1986 (02.12.86), abstract -- --------	1

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
6 December 1995	13 -01- 1996

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/SE 95/01093

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 5209915	11/05/93	JP-A- 4265117	21/09/92
		JP-B- 7024739	22/03/95
EP-A1- 0185630	25/06/86	CA-A- 1255292	06/06/89
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